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# Effects of Stocking Rate, Botanical Composition, and Stream bank Erosion on the Physical Characteristics of the Streamside Zones of Pastures (A Three-Year Progress Report)

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### Summary and Implications

Grazing management practices that allow congregation of cattle near pasture streams may increase sediment, phosphorus, and pathogen loading of the streams by removing the vegetation and causing manure accumulation near the streams. To assess the effects of stocking rate and pasture characteristics on the risk of nonpoint source pollution of pasture streams, forage sward height, bare and manure-covered soil, forage species, and erosion were measured along the banks of streams in 13 pastures on 12 cow-calf operations in southern Iowa. Mean sward heights, and bare and manure-covered soil were different ($P<0.0001$) between the 13 pastures. There were also month differences for mean sward height and manure-covered ground ($P<0.0001$), but not for bare soil ($P>0.05$). The proportions of vegetation species as tall fescue, reed canarygrass, clover, or sedge were different ($P<0.05$) between pastures. Proportions of tall fescue, reed canarygrass, Kentucky bluegrass, bromegrass, orchardgrass, and sedge in the vegetation species were different ($P<0.05$) between months. Pastures with the least proportion of tall fescue and greatest proportion of reed canarygrass had the least amount of bare soil within the streamside zones of pastures. Stepwise multiple regressions were calculated to predict using vegetative species, and sampling interval and annual stocking rates of cattle on the 13 pastures. Sward height decreased as tall fescue, bluegrass, legumes, and annual stocking of cow-days per acre increased ($r^2=0.56$). The proportion of soil that was bare increased as the proportion of legumes increased and decreased as the proportion of reed canarygrass increased ($r^2=0.35$). Manure-covered ground increased as the stocking rate per acre per sampling interval and the proportions of tall fescue and bluegrass in the vegetation increased, and decreased as broadleaf weeds and sedge increased ($r^2=0.47$). Increased stocking rates will result in decreases in forage sward height and increases in manure cover in streamside zones. The presence of tall fescue may also increase cattle activity near streams reducing sward height and increasing manure-covered soil in the streamside zone. Annual stream bank erosion rates were not correlated ($r^2=0.001$) to annual cattle stocking densities per stream foot or acre. The greatest amount of erosion occurs during the spring grazing season, indicative of the freeze-thaw cycle and hydrological effects.

### Introduction

Grazing management practices that allow cattle to congregate near pasture streams may result in the loss of vegetative cover and promote accumulation of manure near the streams. These conditions increase the risk of loading of the streams with sediment, phosphorus, and pathogens carried in precipitation runoff. Furthermore, the loss of vegetation and increased compaction associated with concentrated cattle traffic may promote stream bank erosion causing further impairment of stream water quality.

Previous research has shown that management practices like rotational stocking with flash-grazing of streamside paddocks or restricting stream access to stabilized crossings increased the proportion of vegetative cover and sward height of forage while reducing the proportion of ground covered with manure near streams in smooth bromegrass pastures. Therefore, nonpoint source pollution of these streams should be reduced by these practices. However, the efficacy of grazing management practices on sward height, vegetative cover, and concentration of manure are likely related to stocking rate and other factors such as the botanical composition or shade distribution in pastures that influence congregation of cattle near streams.

The objective of this project was to evaluate the effects of stocking rate of pastures and the botanical composition of the pastures' streamside zone on the forage sward height, the proportions of bare and manure-covered ground, and erosion along the banks of pasture streams.

### Materials and Methods

Thirteen pastures on 12 cooperating farms in the Rathbun Lake watershed were identified as appropriate for the project in the fall of 2006. Pastures ranged in size from 7 to 265 acres and had stream reaches of 948 to 5,511 feet that drained watersheds of 624 to 13,986 acres. At the initiation of the experiment, two of the pastures were ungrazed vegetative buffers. However, grazing of one of these pastures was initiated in October, 2007. Producers of these operations recorded the number of cows, heifers, and bulls stocked in these pastures as they entered and left the pasture from November, 2006 to November, 2009.

Bi-monthly, from May through November, in 2007, 2008 and 2009, proportions of bare and manure-covered ground and the forage sward height and vegetation species were measured on both sides of the stream at up to 30 locations at 100-foot intervals along the stream in each pasture. Proportions of bare and manure-covered were measured perpendicular to the stream by a line transect method over 50 feet, beginning at the edge of the stream. Sward height was measured with a falling plate meter (8.8 lb/yd$^2$) and vegetation species was identified at the mid-point of the transect line. Sward height was not measured at sites in which brush was the major vegetative species. Vegetation species observed included tall fescue, reed canarygrass, Kentucky bluegrass, smooth bromegrass, orchardgrass, timothy, legumes (white or red clover), sedge, weed grasses (primarily foxtail), broadleaf weeds (largely giant ragweed, nettles and wild parsnips), and brush (primarily multiflora rose). Botanical composition was calculated as a proportion of the major vegetative species located at each vegetated site.

Cow-days for each pasture were calculated for each sampling interval as: Cow-days = (Number of cows x days stocked) + (Number of heifers x 0.86 x days stocked) + (Number of bulls x 1.2 x days). Stocking rates were calculated on area and distance bases by dividing the cow-days by the pasture acres or stream reach length and expressed either for the interval between sampling periods or the total year.

Differences in the proportions of bare and manure-covered, forage sward height, and the proportion of each vegetative species between farms were analyzed by analysis of variance using years as replicates.

Regression equations were calculated to quantify the relationship between the dependent variables of sward height and proportion of ground that was bare or manure-covered with independent variables of stocking rates per pasture acre or foot of stream reach or the proportion of each vegetative species. Stepwise multiple regressions were also calculated with independent variables of stocking rate per acre or foot of stream reach on either a sampling period or annual basis and the proportion of each vegetative species.

Stream bank erosion was measured during spring, summer, and fall grazing seasons over the three-year experimental period to evaluate cattle stocking density on erosion of the stream banks. Because the dates of pasture measurements were different for stream bank erosion and the proportion of bare and manure-covered ground measurements, yearly stocking rates per pasture acre or foot of stream reach were regressed against the yearly stream bank erosion measurements to determine a correlation.

## Results and Discussion

Mean sward heights, and bare and manure-covered soil were different ($P<0.0001$; Table 1) between the 13 pastures. There were also month differences for mean sward height and manure-covered ground ($P<0.0001$), but not for bare soil ($P>0.05$).

Mean sward height, in centimeters (Table 2), across sampling intervals decreased from July to November. The low sward height of pastures in November seems to imply that the stream banks might be more susceptible to erosion and sediment and nutrient losses in precipitation run-off over winter.

The proportion of vegetative species were different between farms for tall fescue ($P<0.0001$), reed canarygrass ($P<0.0001$), clover ($P<0.0001$) and sedge ($P<0.0001$). Farms 3, 4, 9, and 13 had the least proportion of vegetated sites as tall fescue, but the highest proportion of reed canarygrass. These farms also had the least amount of bare soil in the streamside zones. These factors may provide a critical understanding of vegetative species that may help to decrease the percentage of bare soil in the streamside zones of pastures. The proportions of vegetated species as tall fescue, reed canarygrass, Kentucky bluegrass, smooth bromegrass, orchardgrass, and sedge differed ($P<0.02$) between sampling intervals. The proportion of tall fescue in the pastures was greater in November than May, July, and September. However, the proportion of Kentucky bluegrass, smooth bromegrass, and orchardgrass were greater in May than July, September, and November. Proportion of reed canarygrass was greater in May than July and September, but was not different than November. The proportions of sedge in the pastures were greatest during the warm seasons of July and September, than November, but were not different than May. These variations in species prevalence may imply that cattle are selecting more palatable vegetative species early in the growing season, but the decreasing the sward height late in the grazing season allowed more aggressive vegetative species to take over the streamside zones of pastures.

Of the methods for expressing stocking rate, the period stocking rate per stream foot (cow-day/stream foot) was most highly related to the forage sward height (cm) measured approximately 25 feet from the stream ($y=16.30-13.53x+3.18x^2$; $r^2=0.31$; Figure 1). In stepwise multiple regressions, sward heights in the streamside zone decreased as the proportions of tall fescue, legumes, Kentucky bluegrass, and period stocking rate of cow-days/stream foot increased ($r^2=0.56$; Table 3).

The proportions of bare soil along the stream banks did not differ ($P>0.05$) between sampling intervals, but did differ by farms ($P<0.0001$). The proportion of bare soil along the stream banks (%) was only weakly related to the period stocking rate per stream foot ($y=10.45+11.56x-3.02x^2$; $r^2=0.16$; Figure 2). In stepwise multiple regressions, the proportion of bare soil decreased as the proportions of reed canarygrass and legumes increased. These variables accounted for 35% of the variation in the proportion of soil that was bare. Because period or annual stocking rate measures was not accounted for within the 35% variation, natural factors like stream flow and rainfall have larger effects on bare soil adjacent to streams than cattle traffic. Measuring bare soil perpendicular to the streams combined measurements of the eroded stream banks with variable lengths within the riparian zone

The proportion of manure-covered soil within 50 feet of the stream (%) increased as the period stocking rate per acre (cow-days per acre) increased ($y=0.160+0.011x-0.00003x^2$; $r^2=0.35$; Figure 3). In multiple stepwise regressions, the proportion of manure-covered ground increased as the annual stocking rate of cow-days per stream foot and the proportions of tall fescue and Kentucky bluegrass increased and the proportions of broadleaf weeds and sedge decreased. These variables accounted for 47% of the variation in manure-covered soil and may represent the effects of stocking rate of areas with the most commonly grazed species.

Seasonal erosion rates, in centimeters (Figure 4), across the three years imply the greatest amount of erosion occurs during the spring grazing season. However, heavy rainfall amounts have been reported during these seasons, which may imply that as the banks of streams become wet, they lose their shear strength and with excessive amounts of rainfall, stream bank erosion occurs. Due to the above normal rainfall amounts prior to entering or exiting winter, the saturated stream banks undergoes the freeze-thaw cycle, and the greatest likelihood for stream bank erosion to occur is during this period. Because, annual stocking density per stream foot was not correlated to annual stream bank erosion ($y=6.86-0.11x+0.02x^2$; $r^2=0.001$; Figure 5), implications are natural factors like stream flow and rainfall have larger effects on stream bank erosion than cattle traffic. However, management strategies may be implemented during periods of excessive rainfall to minimize treading effects of cattle in streamside zones that may indirectly lead to stream bank erosion.

Results imply that increasing stocking rate will result in decreases in sward height and increases in manure cover in streamside zones. However, the effects of stocking rate on the proportion of bare soil adjacent to streams and stream bank erosion are small. A greater prevalence of tall fescue in the streamside zone may cause increased cattle activity near streams reducing sward height and increasing manure-covered soil in the streamside zone or may itself be the result of cattle congregation in the streamside zone promoted by other factors.

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**Table 1. Average proportions of sward height, percentage of bare soil, and percentage of fecal-covered soil within 50 feet of the stream in 13 pastures in the Rathbun Lake Watershed.**

| Pasture | Sward height (cm) | Bare soil (%) | Manure-covered soil (%) |
|---|---|---|---|
| 1 | $5.66^{c}$ | $13.35^{f}$ | $0.96^{ab}$ |
| 2 | $6.47^{c}$ | $17.11^{d}$ | $0.51^{cde}$ |
| 3 | $23.38^{a}$ | $5.92^{gh}$ | $0.00^{g}$ |
| 4 | $13.78^{b}$ | $8.52^{g}$ | $0.55^{cd}$ |
| 5 | $6.33^{c}$ | $11.78^{f}$ | $0.29^{defg}$ |
| 6 | $4.48^{c}$ | $31.09^{b}$ | $0.24^{efg}$ |
| 7 | $5.90^{c}$ | $17.79^{cd}$ | $1.02^{a}$ |
| 8 | $5.59^{c}$ | $13.88^{ef}$ | $0.55^{cd}$ |
| 9 | $16.50^{b}$ | $7.10^{g}$ | $0.21^{fg}$ |
| 10 | $6.25^{c}$ | $20.81^{c}$ | $0.37^{def}$ |
| 11 | $2.36^{c}$ | $36.72^{a}$ | $0.86^{ab}$ |
| 12 | $4.66^{c}$ | $16.54^{de}$ | $0.62^{bc}$ |
| 13 | $23.98^{a}$ | $3.20^{h}$ | $0.00^{g}$ |
| Average | 9.64 | 15.68 | 0.48 |

[a,b,c,d,e,f,g]Within a column, least squares means without a common subscript differ ($P<0.05$).

**Table 2. Average sward height, bare ground, and manure-cover in the streamside zones of pastures across sampling months.**

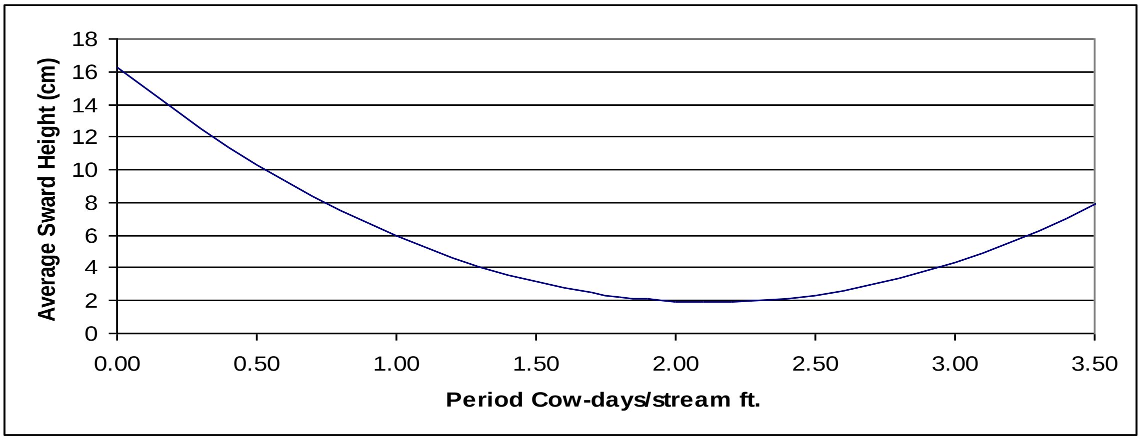
| Sampling months | Sward height (cm) | Bare soil (%) | Manure-covered soil (%) |
|---|---|---|---|
| May | 11.85[ab] | 16.44 | 0.52[ab] |
| July | 14.06[a] | 14.74 | 0.48[ab] |
| September | 8.71[ab] | 15.99 | 0.34[b] |
| November | 3.94[c] | 15.54 | 0.56[a] |
| Average | 9.64 | 15.68 | 0.48 |

[a,b,c]Within a column, least squares means without a common subscript differ ($P<0.05$).

**Table 3. Stepwise multiple regressions predicting sward height, bare ground, and manure cover in the streamside zones of pastures from stocking rate and botanical composition data.**

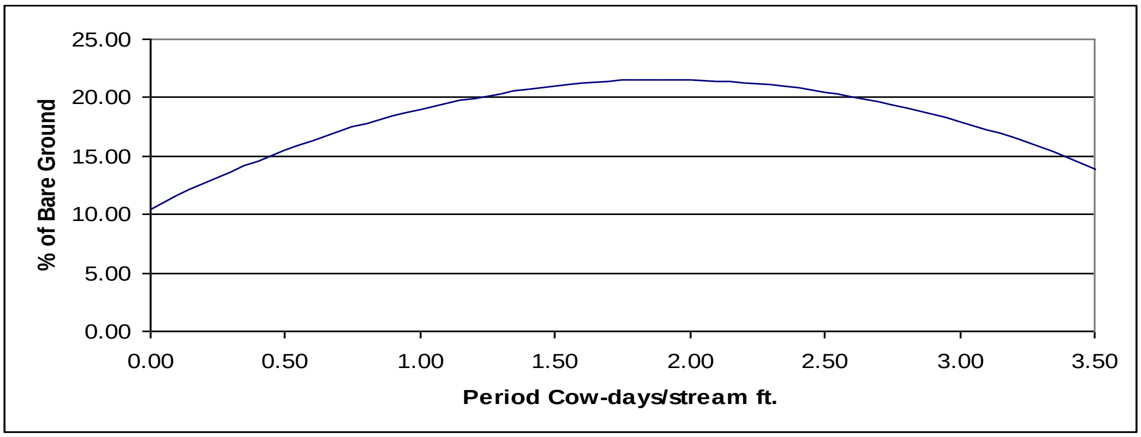
| Dependent variable | Independent variables | Coefficients | Partial $r^2$ |
|---|---|---|---|
| **Sward height, cm** | Intercept | 23.07234 | |
| | Tall fescue, % of vegetation | -0.21339 | 0.43 |
| | Legumes, % of vegetation | -0.27380 | 0.06 |
| | Bluegrass, % of vegetation | -0.16093 | 0.06 |
| | Stocking rate, cow-days/stream ft. by period | -1.20307 | 0.01 |
| | | **Total** | **0.56** |
| **Bare soil, %** | Intercept | 18.89681 | |
| | Reed canarygrass, % of vegetation | -0.19421 | 0.33 |
| | Legumes, % of vegetation | 0.18874 | 0.02 |
| | | **Total** | **0.35** |
| **Manure cover, %** | Intercept | 0.18096 | |
| | Annual stocking rate, cow-days/stream ft. | 0.06781 | 0.34 |
| | Tall fescue, % of vegetation | 0.00413 | 0.05 |
| | Broadleaf weeds, % of vegetation | -0.00712 | 0.04 |
| | Bluegrass, % of vegetation | 0.00621 | 0.03 |
| | Sedge, % of vegetation | -0.03082 | 0.01 |
| | | **Total** | **0.47** |

**Figure 1. Correlations of stocking rate by period on forage sward height within 50 feet of stream.**



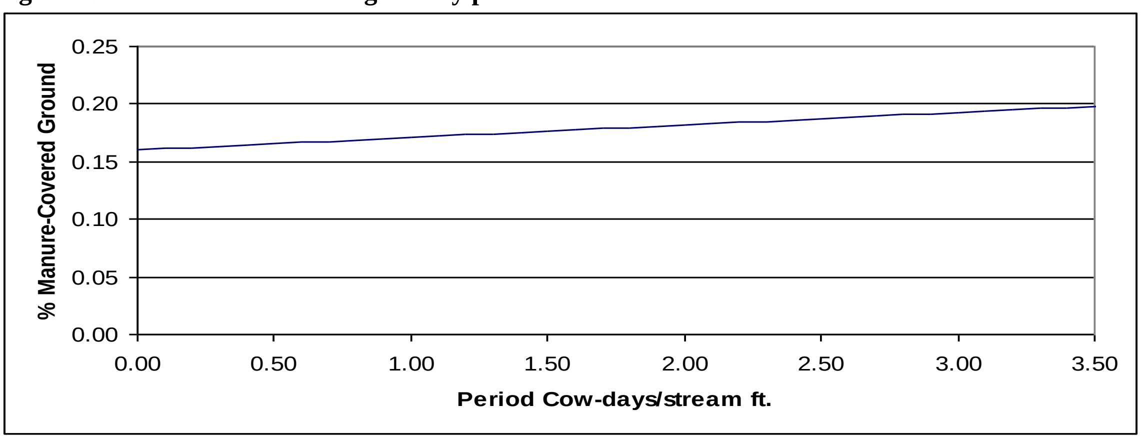

$y=16.30-13.53x+3.18x^2$; $r^2=0.31$

**Figure 2. Correlations of stocking rate by period on bare soil within 50 feet of stream.**




$y=10.45+11.56x-3.02\ x^2$; $r^2=0.16$

**Figure 3. Correlations of stocking rate by period on manure-covered soil within 50 feet of stream.**




$y=0.160+0.011x-0.00003x^2$; $r^2=0.35$

**Figure 4. Seasonal erosion rates by year of all farms combined.**

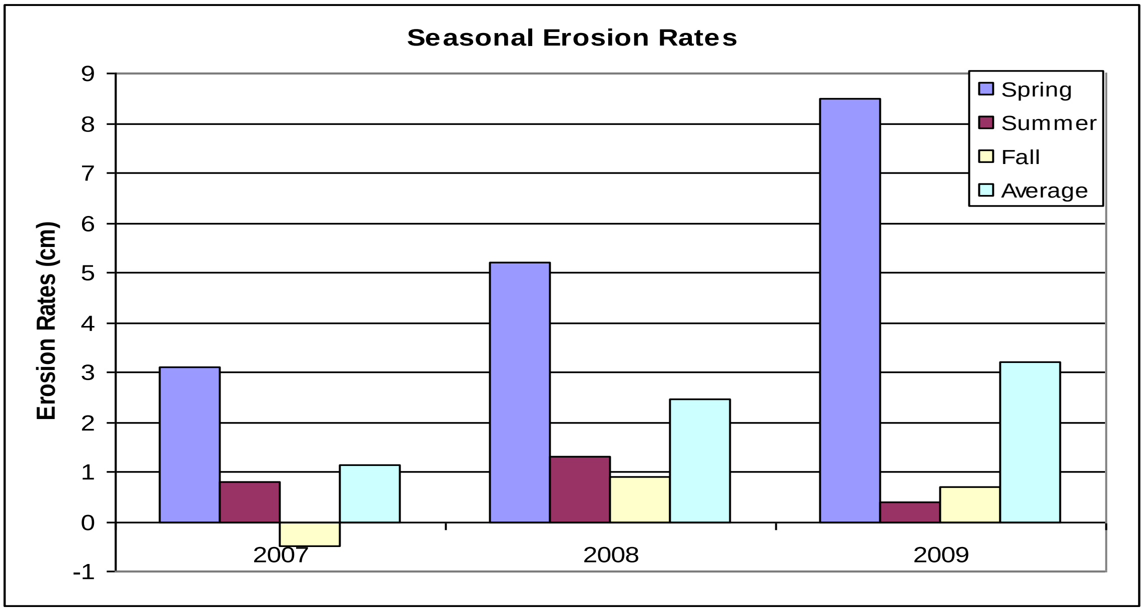
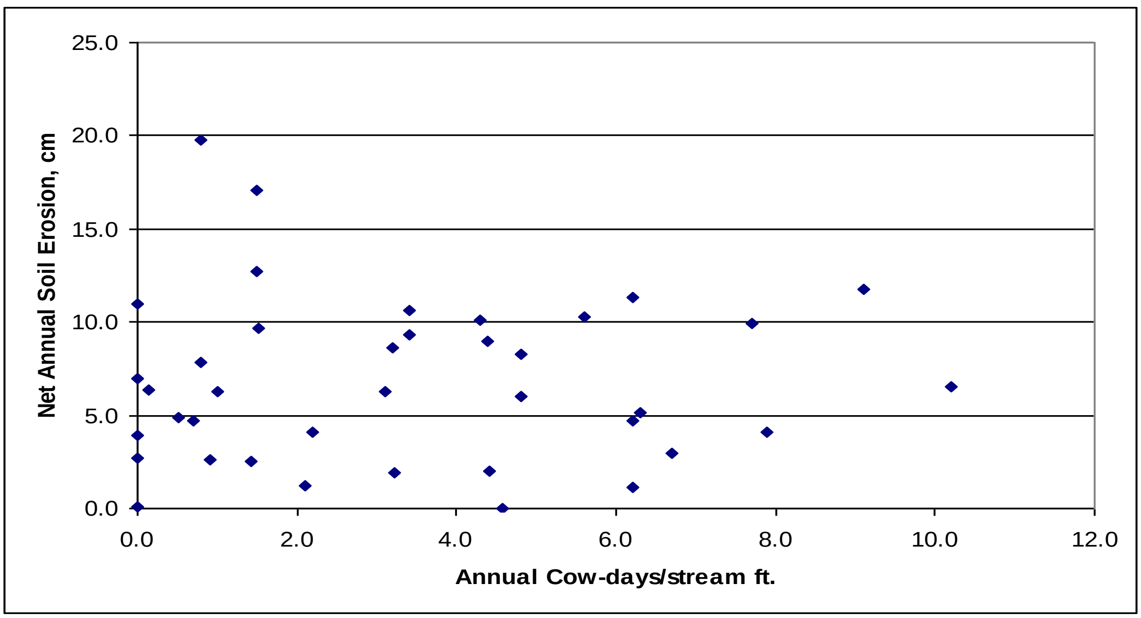



**Figure 5. Correlations of annual stocking rate on net annual erosion from banks of streams in the Rathbun Lake Watershed.**




$y=6.86-0.11x+0.02x^2$; $r^2=0.001$